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Functional Assessment of Restrictive Eating: A Three-Study Clinically Heterogeneous and Transdiagnostic Investigation

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Restrictive eating is common and associated with negative psychological outcomes across the life span and eating disorder (ED) severity levels. Little is known about functional processes that maintain restriction, especially outside of narrow diagnostic categories (e.g., anorexia nervosa). Here, we extend research on operant four-function models (identifying automatic negative, automatic positive, social negative, and social positive reinforcement functions) that have previously been applied to nonsuicidal self-injury (NSSI), binge eating, and purging to restricting. We assessed restrictive eating functions in three samples: clinically heterogeneous adolescents (Study 1: $N = 457$), transdiagnostic adults (Study 2: $N = 145$), and adults with acute or recently weight-restored anorexia nervosa (Study 3: $N = 45$). Study 1 indicated the four-function model was a good fit for restricting (root mean square error of approximation [RMSEA] = .06, Tucker-Lewis index [TLI] = .88). This factor structure replicated in Study 2 (comparative fit index [CFI] = .97, RMSEA = .07, TLI = .97, standardized root mean square residual [SRMR] = .09). Unlike NSSI, binge eating, and purging, which have been found to primarily serve automatic negative reinforcement functions, all three present studies found automatic positive reinforcement was most highly endorsed (by up to 85% of participants). In Studies 1 and 3, automatic functions were associated with poorer emotion regulation ($ps < .05$). In Study 1, social functions were associated with less social support ($ps < .001$). Across studies, automatic functions were associated with greater restriction $ps < .05$). Functions varied slightly by ED diagnosis. Across ED presentation, severity, and developmental stage, restrictive eating may be largely maintained by automatic positive reinforcement, with some variability across presentations. Continued examination of restrictive eating functions will establish processes that maintain restriction, allowing more precise treatment targeting for these problematic behaviors.

General Scientific Summary

Self-destructive behaviors have been found to be maintained via positive and negative reinforcement, with both automatic and social contingencies. The current series of studies extends this four-function model to restrictive eating, finding that unlike other self-destructive behaviors (e.g., nonsuicidal self-injury, binge eating, and purging, which all primarily serve automatic negative reinforcement), restrictive eating is primarily maintained by automatic positive reinforcement. Findings replicated across three separate samples varying by developmental stage, diagnosis, illness stage/severity, and administration method (online vs. in person).

Keywords: restrictive eating, functions, four-function model, assessment

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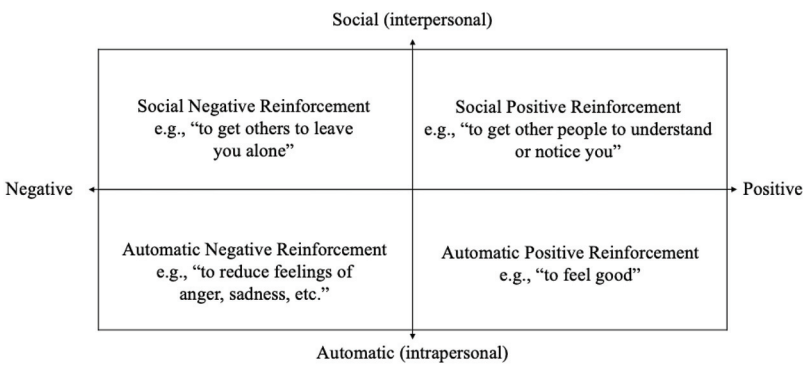
Restrictive eating (i.e., limitation of caloric intake in a disordered manner inadequate for long-term maintenance of appropriate weight and/or health; Haynos & Fruzzetti, 2015) is extremely prevalent throughout the life span. Over half of adolescents and two thirds of adults report disordered restrictive eating (Neumark-Sztainer et al., 2002; Reba-Harrelson et al., 2009). This transdiagnostic behavior is present across all eating disorder diagnoses, including anorexia nervosa (AN), bulimia nervosa (BN), binge-eating disorder (BED), and other specified feeding and eating disorders (OSFED), and suppresses weight below a biological set-point for many individuals with eating disorders, including those not underweight (Lowe et al., 2018). Restrictive eating is associated with many negative consequences, even among individuals not meeting criteria for an eating disorder diagnosis, including depression (Cairns et al., 2014), substance use (Krahn et al., 1996), and nonsuicidal self-injury (NSSI; Stanford et al., 2017). These findings suggest restrictive eating is a critical treatment target across a range of clinical presentations.

Despite the prevalence and seriousness of restrictive eating, surprisingly little is known about functional processes that maintain and reinforce these behaviors. Prior research has largely taken a syndromal approach to describe constructs that are associated with, increase risk for, or are consequences of restrictive eating (Haynos et al., 2016). These approaches conceptualize behaviors (e.g., restrictive eating) as signs/symptoms of some underlying disease (e.g., AN), and treat disorders based on these formal topographical characteristics (e.g., institute regular meal pattern; Fairburn, 2008). An alternative approach is that exemplified by an established operant learning framework that considers the functional processes that produce and maintain behaviors to understand and ultimately intervene upon the *purpose* of behaviors in the context of conditions that reinforce them (Kazdin, 2012). This approach places less emphasis on understanding the formal goal of a behavior (e.g., NSSI to hurt oneself), and more emphasis on what reinforcement processes make these outcomes desirable (e.g., to alleviate negative emotion).

This functional approach has led to significant advances in the conceptualization, assessment, and treatment of other self-destructive behaviors such as NSSI. Research has demonstrated that NSSI is maintained by negative and positive reinforcement, with automatic (intrapersonal) and social (interpersonal) contingencies (Nock & Prinstein, 2004). Specifically, this four-function model (see Figure 1) posits that NSSI is reinforced by automatic negative (e.g., to reduce negative affect), automatic positive (e.g., increase positive affect), social negative (e.g., avoid social interactions), and social positive (e.g., receive help) reinforcement. Automatic negative reinforcement functions have been most highly endorsed (Nock & Prinstein, 2004). As such, NSSI treatments have primarily focused on substituting nonharmful methods for reducing negative affect or altering the association between NSSI and emotional relief (Linehan, 1993). The four-function model has been replicated for binge eating and purging, with automatic negative reinforcement also emerging as the predominant function maintaining these behaviors (Wedig & Nock, 2010), and guiding treatments targeting negative reinforcement for these behaviors (Wonderlich et al., 2014). This establishes the utility of a functional model and highlights the possibility that topographically distinct behaviors serve the same functions.

Although this comprehensive framework has not yet been applied to restrictive eating, long-standing theoretical accounts are consistent with components of the four-function model. For instance, automatic functions are closely aligned with emotion regulation models, which propose that individuals restrict to regulate emotions, and research in clinical and nonclinical (Harrison et al., 2010; Haynos et al., 2018) samples has demonstrated a strong relationship between restrictive eating to downregulate negative emotions. Less empirical research has investigated restricting to upregulate positive emotions, though evidence also suggests an automatic positive reinforcement function of restricting (Nordbø et al., 2006). Regarding social reinforcement, some models of extreme restrictive eating (e.g., in AN) posit that restricting provides positive social reinforcement (e.g., through initial weight loss compliments, care from others as illness persists; Schmidt & Treasure, 2006). Evidence also suggests individuals may restrict to avoid unwanted social attention, including that of a romantic or sexual nature (Petersen & Hyde, 2013; Root, 1991). These functions are further supported by a substantial literature on neurobiological mechanisms supporting disorders characterized by restrictive eating. Significant evidence suggests structural and functional brain abnormalities in regions supporting threat and reward processing (e.g., frontostriatal and frontolimbic circuitry; Ehrlich et al., 2015; Haynos et al., 2019) and emerging literature suggests altered neurobiological responses to social stimuli in AN (McAdams & Krawczyk, 2011). Together these literatures provide

Figure 1
Four-Function Model



indirect evidence that functions of restrictive eating may also align with the four-function model previously applied to NSSI, binge eating, and purging.

Control may be an additional mechanism maintaining restriction that may or may not fit within the established four-function operant model. Clinically, individuals with AN describe restricting to feel in control of their bodies or their lives (Slade, 1982). This hypothesis motivated Wedig and Nock (2010) to include items assessing control in their functional assessment of binge eating and purging. Results from confirmatory factor analyses suggested the original four-function model (excluding control) provided a better fit for their data. However, the clinical and theoretical importance of control in disorders characterized by extreme restrictive eating (i.e., AN) suggests this behavior may be maintained by a five-function model that includes control.

Although prior studies have provided some insight into potential functions of restrictive eating, most previous research has narrowly focused on AN as a specific diagnosis representative of restrictive eating and assessed functions broadly (e.g., "How is it to have anorexia?"; Nordbø et al., 2006). However, restrictive eating is a transdiagnostic feature present across all eating disorder diagnoses, and associated with significant distress and impairment across the weight spectrum (Crow et al., 2006). As individuals with AN represent just a small subgroup of those who engage in severe restrictive eating, this narrow focus has limited knowledge of transdiagnostic restrictive eating functions, including how functions of restrictive eating may vary according to clinical presentation, severity, or developmental stage. For instance, restrictive eating is associated with numerous negative outcomes even among those without a clinical eating disorder diagnosis (Cairns et al., 2014; Wang et al., 2018). Thus, examining functions only among those with AN limits our understanding of how this harmful behavior is maintained for individuals across the spectrum from subthreshold to acute/severe disordered eating. Additionally, although adolescence is a high-risk time period for the initiation and escalation of restrictive eating, these behaviors continue to be prevalent in adulthood, with many individuals either persisting in restrictive eating from adolescence to adulthood or beginning to restrict in adulthood (Haynos et al., 2018). Theoretical models suggest restrictive eating functions may change over time (Walsh, 2013); however, minimal research has compared functions between different development stages.

To overcome these issues, the current studies examined the application of the four-function model (or five-function model, if considering control an addition function) to restrictive eating using exploratory and confirmatory factor analyses in three samples. We first examined these models in clinically heterogeneous/transdiagnostic samples across of adolescents and adults. Study 1 assessed restrictive functions in an exploratory manner in a large sample of adolescents. Given prior data on the four functions of NSSI, binge eating, and purging, alongside theoretical evidence for a potential fifth function of control, we did not have strong a priori hypotheses about the number of functions that would emerge from this initial dataset, but considered both a four-function or five-function model to be possible. Study 2 provided a confirmatory test of restrictive eating functions identified in Study 1 among adults to determine if the same model fit, and if predominant reinforcement processes maintaining restrictive eating were stable across developmental periods. Study 3 extended further to determine if results replicated in AN to test whether functions were similar in a clinical population known to demonstrate severe restrictive eating leading to significant weight loss.

We also examined correlations between functions of restrictive eating and related clinical characteristics (eating disorder behavior frequency, emotion regulation, and social support) to establish validity of these constructs. We hypothesized that automatic functions would be correlated with poorer emotion regulation (less use of adaptive emotion regulation strategies and more use of maladaptive strategies), given that automatic functions involve engaging in maladaptive behaviors (i.e., restrictive eating) to enhance positive and reduce negative emotional experiences. We also hypothesized that social functions would be correlated with less perceived social support, given that social functions involve engaging in maladaptive behaviors to increase desired social interactions and reduce unwanted social interactions. We did not have a priori hypotheses about correlations between restrictive eating functions and frequency of eating disorder behaviors (restrictive eating, binge eating, and purging) and these analyses were considered exploratory. The current studies aimed to provide the first investigation of restrictive eating functions through a comprehensive theoretical framework to clarify the reinforcement processes that maintain restrictive eating across diagnostic, severity, and developmental spectra.

Study 1

Method

Participants and Procedure

We recruited participants as part of a larger online longitudinal study on self-injurious thoughts and behaviors among adolescents engaging in restrictive eating. Recruitment occurred primarily via paid Instagram advertisements targeting users who interacted with topics related to restrictive eating (example keywords: "fasting," "diet food," and "weight loss"). Interested users completed a brief screening to determine eligibility (age 12–14 years to capture a high-risk period for NSSI onset, English speaking, living in the United States, reporting 2+ past-month episodes of restrictive eating, corresponding with prior studies; Fox, O'Sullivan, et al., 2019). "Filler items" were used to obscure inclusion criteria and decrease likelihood of people misrepresenting their eligibility. People who met inclusion criteria and provided assent to participate were sent a link to the online study; parental consent was waived for this study, as is common for online research methods with adolescents (Smith et al., 2021). Research and recruitment procedures were approved by the Harvard University Institutional Review Board (IRB protocol/study title: IRB18-0350; "Longitudinal investigation of dietary restriction").

After completing the screener (N = 7,217), 696 qualified participants completed study questionnaires; all participants were entered into a lottery for $50 gift cards. The final analytic sample included 457 participants (M_{age} = 13.68, SD = .56 years). Most participants (n = 414; 91%) reported being assigned female sex at birth, and most identified as female gender (n = 332; 73%); 81 participants (18%) identified as transgender or nonbinary. A total of 134 participants (29%) identified as heterosexual, 54 (12%) as gay or lesbian, 141 (31%) as bisexual, 46 (10%) as unsure, 50 (11%) as

pansexual, and 15 (3%) as asexual. Regarding race/ethnicity, 291 participants (64%) identified as White/Caucasian, 37 (8%) as Hispanic/Latino, 11 (2%) as Black/African American, 23 (5%) as Asian/Asian American/Pacific Islander, four (1%) as Native American/American Indian, and 82 (15%) as biracial or multiracial. A total of 203 participants provided weight and height data to calculate Body Mass Index (BMI); among these participants, average BMI was 23.50 (*SD* = 5.42).

Measures

Functional Assessment of Maladaptive Behaviors (FAMB; Wedig & Nock, 2010). We adapted the FAMB (see **Table 1**) to assess functions of restrictive eating. The FAMB asks participants to indicate how often they engage in a specified behavior (in the current study, restrictive eating) for reasons reflecting automatic positive, automatic negative, social positive, and social negative reinforcement functions from 0 (*never*) to 3 (*often*). We modified the original FAMB to better reflect the phenomenology of restrictive eating based on expert consensus. Specifically, we added two items assessing automatic positive reinforcement (to feel proud, to feel good), one item assessing automatic negative reinforcement (to punish myself), one item assessing social negative reinforcement (to avoid attention from other people), and the four items assessing control (to get control of a situation, feel in control of your life, feel in control of your body, control how you feel) from Wedig and Nock (2010).

Dietary Restriction Screener (DRS; Haynos & Fruzzetti, 2015). The DRS is a single-item measure assessing past-month restrictive eating. The DRS first clearly defines restrictive eating, provides examples, and asks participants to indicate whether they have engaged in restrictive eating in the past month. We slightly adapted the DRS to assess past-month frequency of restrictive eating (full measure in online supplemental materials). The DRS has been found to predict eating disorder symptoms, intended and actual food intake, and clinical severity in several studies (Fox, Wang, et al., 2019; Wang et al., 2018), including predicting reduced objective in vivo food intake better than other measures of restrictive eating (Haynos & Fruzzetti, 2015).

Eating Disorder Examination-Questionnaire (EDE-Q; Fairburn & Beglin, 2008). The youth EDE-Q assessed eating-disorder psychopathology. The EDE-Q has shown strong validity (Berg et al., 2012) and test–retest reliability (Rose et al., 2013). For the current study, we asked participants whether they owned and knew how to use a scale and a tape measure/other instrument for measuring height. Participants who responded "yes" were asked to measure and report their weight and height.

Emotion Regulation Questionnaire-Children and Adolescents (ERQ-CA; Gullone & Taffe, 2012). The ERQ-CA assesses two emotion regulation strategies: cognitive reappraisal (reframing emotional stimuli to alter their impact) and suppression (active inhibition of emotional responses), with the former generally considered an adaptive, and the later a maladaptive, emotion regulation strategy. The ERQ-CA has excellent construct and convergent

Table 1
Modified Functional Assessment of Maladaptive Behavior

Item	Study 1 (*N* = 490)		Study 2 (*N* = 145)		Study 3 (*N* = 45)	
	M (*SD*)	%	*M* (*SD*)	%	*M* (*SD*)	%
To control how you feel	1.78 (1.18)	62.6%	1.99 (1.18)	71.0%	2.23 (1.03)	79.6%
To feel as though you are in control of your body	2.17 (1.08)	76.5%	2.43 (0.93)	84.8%	2.4 (0.91)	84.4%
To get control of a situation	1.56 (1.22)	54.3%	1.96 (1.17)	68.3%	1.98 (1.11)	72.7%
To feel as though you are in control of your life	2.00 (1.09)	71.6%	2.34 (0.98)	82.8%	2.27 (0.99)	80.0%
To feel strong/powerful	1.32 (1.24)	46.0%	1.98 (1.16)	72.4%	1.59 (1.23)	56.8%
To feel good	1.90 (1.16)	68.1%	2.02 (1.16)	70.3%	2.27 (0.99)	80.0%
To feel proud of yourself	2.18 (1.09)	76.7%	2.27 (1.11)	79.3%	2.09 (1.02)	73.3%
To punish yourself	2.04 (1.06)	73.8%	2.12 (1.05)	77.9%	1.78 (1.02)	62.2%
To feel something at all, even if it's pain	1.35 (1.19)	46.4%	0.88 (1.09)	27.6%	0.82 (1.05)	24.4%
To feel relaxed	0.86 (1.06)	27.3%	1.09 (1.14)	39.3%	1.56 (1.08)	55.6%
To ground yourself/return from a dissociative state	0.97 (1.13)	32.10%	0.82 (1.10)	26.20%	1.04 (1.21)	33.3%
To cope with/relieve stress	1.33 (1.09)	46.80%	1.74 (1.21)	59.30%	2.36 (0.88)	86.7%
To prevent bad feelings	1.64 (1.16)	59.10%	1.91 (1.17)	69.70%	1.98 (1.06)	71.1%
To slow down racing thoughts	0.73 (1.00)	22.60%	0.92 (1.14)	27.60%	1.76 (1.07)	48.9%
To escape/avoid/stop bad feelings	1.50 (1.09)	51.80%	1.63 (1.23)	55.90%	2.27 (0.99)	84.4%
To relieve anxiety	1.14 (1.13)	37.00%	1.65 (1.25)	56.60%	2.36 (0.98)	82.2%
To reduce feelings of anger, sadness, loneliness, anxiety, etc.	1.52 (1.08)	50.60%	1.73 (1.17)	62.10%	2.16 (1.00)	80.0%
To feel special	0.43 (0.84)	12.90%	1.07 (1.16)	37.90%	1.07 (1.03)	42.2%
To get attention	0.40 (0.80)	11.60%	0.68 (1.02)	22.80%	0.47 (0.87)	15.6%
To get other people to understand or notice you	0.73 (1.03)	23.00%	0.86 (1.17)	30.30%	0.71 (0.99)	20.0%
To communicate to others how badly you feel inside	0.76 (1.01)	26.60%	0.90 (1.11)	31.00%	0.8 (0.97)	20.0%
To let others know how desperate you were feeling	0.65 (1.01)	21.60%	0.83 (1.11)	27.60%	0.64 (0.96)	15.6%
To get a reaction from someone even if it's negative	0.72 (1.05)	23.50%	0.88 (1.15)	28.30%	0.47 (0.87)	11.1%
To avoid attention from other people	0.98 (1.11)	34.5%	0.92 (1.11)	31.7%	0.87 (0.94)	24.4%
To give yourself something to do when you are bored	0.41 (0.81)	13.0%	0.67 (1.03)	22.1%	0.69 (0.97)	22.2%
To avoid being with other people	0.46 (0.90)	15.7%	0.88 (1.10)	32.4%	0.64 (0.86)	20.0%
To avoid school, work, or other activities	0.22 (0.64)	6.2%	0.46 (0.86)	17.2%	0.71 (0.89)	24.4%
To avoid having to do something unpleasant you don't want to do	0.69 (1.03)	22.1%	0.83 (1.03)	26.2%	1.11 (1.05)	37.8%
To give yourself something to do when you are alone	0.59 (0.93)	18.5%	0.89 (1.13)	29.7%	1.02 (1.06)	33.3%

validity, and good internal consistency and stability in youth (Gullone & Taffe, 2012).

Multidimensional Scale of Perceived Social Support (MSPSS; Zimet et al., 1988). The MSPSS assessed perceived social support from family, friends, and significant others. The MSPSS has good construct validity, discriminant validity, and test–retest reliability among adolescents (Bruwer et al., 2008).

Data Analysis

Analyses and data visualizations were performed in R (R Core Team, 2019) via *psych* (Revelle, 2017), *lavaan* (Rosseel, 2012), *lme4* (Bates et al., 2019, p. 4), *lsmeans* (Lenth, 2018) *ggplot2* (Wickham et al., 2020), and *corrplot* (Wei et al., 2017) packages. We first used descriptive statistics to examine clinical characteristics and average endorsement of restrictive eating functions. Second, to explore dimensionality of restrictive functions, we followed recommendations by Mair (2018). Specifically, we ran an exploratory factor analysis (EFA) to identify latent factors based on the correlation structure of the manifest variables in the FAMB. The number of factors to extract was determined by multiple criteria, including ad hoc criteria, parallel analysis, statistical goodness-of-fit indices, and interpretability. Regarding ad hoc criteria, we plotted and evaluated a scree plot. A scree plot is also the output of parallel analysis, which performs a full model fit on (a) the original dataset, (b) resampled bootstrap data, and (c) random uncorrelated data. In this case, a factor is considered "significant" if its eigenvalue is >95% quantile (red lines in Figure 2) of resampled or random data. We used root mean squared error of approximation (RMSEA) and Tucker-Lewis index (TLI) as goodness-of-fit indices. Guidelines suggest cutoffs close to <.06 for RMSEA and >.95 for TLI indicate good fit (Hu & Bentler, 1999). After determining the number of factors to extract, we fit an EFA using oblique rotation (as we expected factors to be correlated) and used the final interpretability criterion by examining item factor loadings. Finally, we tested for differences in endorsement of functions using a linear multilevel model and differences in functions across eating disorder diagnoses using linear regression models (both adjusted with Tukey's honest significance difference (HSD) to evaluate pairwise significant differences). We also examined correlations between functions and clinical characteristics.

Results

Clinical Characteristics and Frequency of Restrictive Eating

Participants reported an average of 12.75 past-month restrictive eating (*SD* = 10.06, range = 2–60), 5.45 binge-eating (*SD* = 7.00, range = 0–46), and 6.49 purging (*SD* = 9.76, range = 0–80) episodes. The average EDE-Q score was 3.80 (*SD* = 1.11), above the clinical cut-off of 3.5 (Fairburn & Beglin, 2008), indicating this sample was within the clinical range. Using the EDE-Q diagnostic algorithm (Berg et al., 2012) for participants who reported measured weight/height, 15 participants (7.6%) met criteria for AN, 21 (10.3%) for BN, 21 (10.3%) for BED, and 145 (71.1%) for OSFED; ^{2}(1.0%) did not meet criteria for an eating disorder.

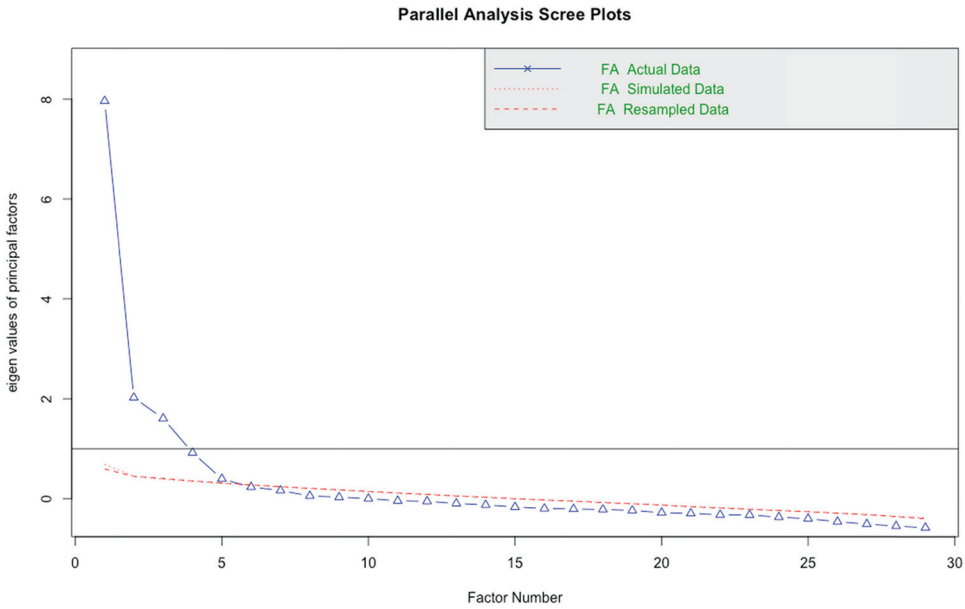
Table 1 presents average item endorsement and percentage of participants endorsing each item "sometimes" or "often." The most highly endorsed items were to feel proud, to feel in control of one's body, to punish oneself, to feel in control of one's life, and to feel good.

Exploratory Factor Analysis

The scree plot (see Figure 2) indicated the "elbow" occurred at four factors, which was also the number of factors with an

Figure 2

Exploratory Factor Analysis Scree Plot of Restrictive Eating Functions in Study 1



Note. See the online article for the color version of this figure.

eigenvalue > 1. However, comparing eigenvalues of the raw data to those from parallel analysis indicated five factors were significant (i.e., >95% quantile of eigenvalues from random and resampled data). Fit indices indicated the five-factor model was a slightly better fit (RMSEA = .05, TLI = .94) than the four-factor model (RMSEA = .06, TLI = .88). However, factor loadings revealed only two items (restricting to feel special, restricting to get attention) loaded onto the fifth factor in the five-factor model, whereas 6–10 items loaded on each factor in the four-factor model. Therefore, considering all criteria (ad hoc, parallel analysis, fit statistics, and interpretability) in concert, we decided to extract four factors for the final solution.

Examination of factor loadings from the oblique-rotated model (see Figure 3) indicated seven items assessing restricting to increase positive emotions (e.g., feel proud) and feel in control loaded onto an automatic positive reinforcement factor. Ten items assessing restricting to reduce negative emotions (e.g., reduce anger/sadness) and for self-punishment loaded onto an automatic negative reinforcement factor. Six items assessing restricting to increase desired social interactions (e.g., get people to understand you) loaded onto a social positive reinforcement factor. Finally, six items assessing restricting to reduce unwanted social interactions (e.g., to avoid attention) loaded onto a social negative reinforcement factor.

Comparisons Among Functions and Clinical Characteristics

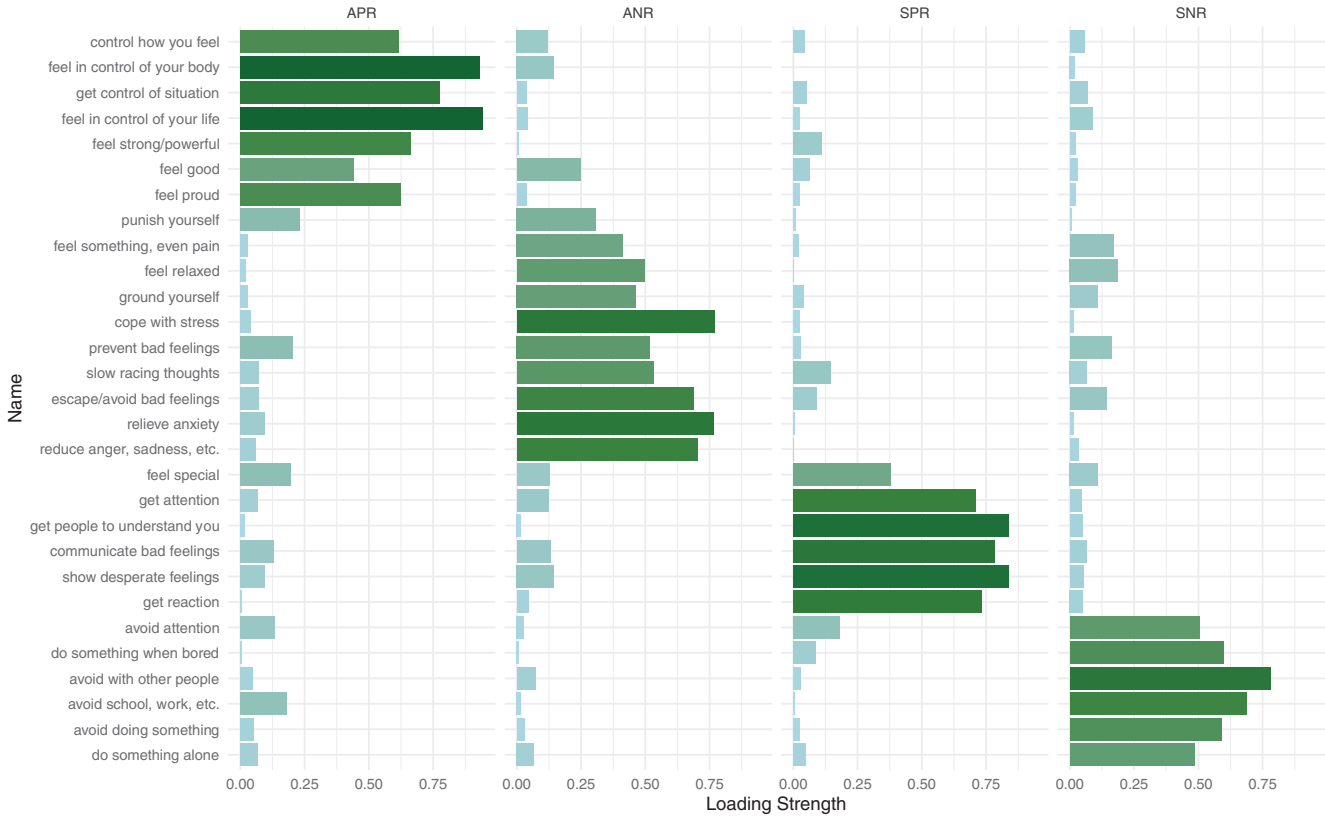
There were significant differences in endorsement of the four functions ($F(3, 1333.6) = 493.17$, $p < .001$); endorsement of automatic positive reinforcement functions was significantly higher than all other functions ($ps < .001$). Endorsement of automatic negative reinforcement functions was also significantly higher than social functions ($ps < .001$). There were no significant differences in social positive and negative functions ($p = .58$).

Correlations are shown in Figure 4 All four functions were significantly correlated ($rs > .30$, $p < .001$). The automatic negative function was associated with greater past-month restrictive eating ($r = .30$, $p < .001$) and purging ($r = .21$, $p < .001$); automatic positive reinforcement was also associated with greater past-month restrictive eating ($r = .24$, $p < .001$). As hypothesized, automatic negative and positive functions were associated with greater emotional suppression ($rs = .10$, $ps < .05$), and automatic negative reinforcement was associated with less use of reappraisal ($r = -.16$, $p = .001$). Also as hypothesized, social negative reinforcement was associated with less perceived social support ($r = -.17$, $p < .001$). Of note, these effect sizes were fairly small.

There were significant differences in social negative reinforcement ($F(4, 195) = 3.48$, $p = .01$) across diagnoses; adolescents with BN scored significantly higher than those with OSFED ($p = .02$). No significant differences between diagnoses emerged for

Figure 3

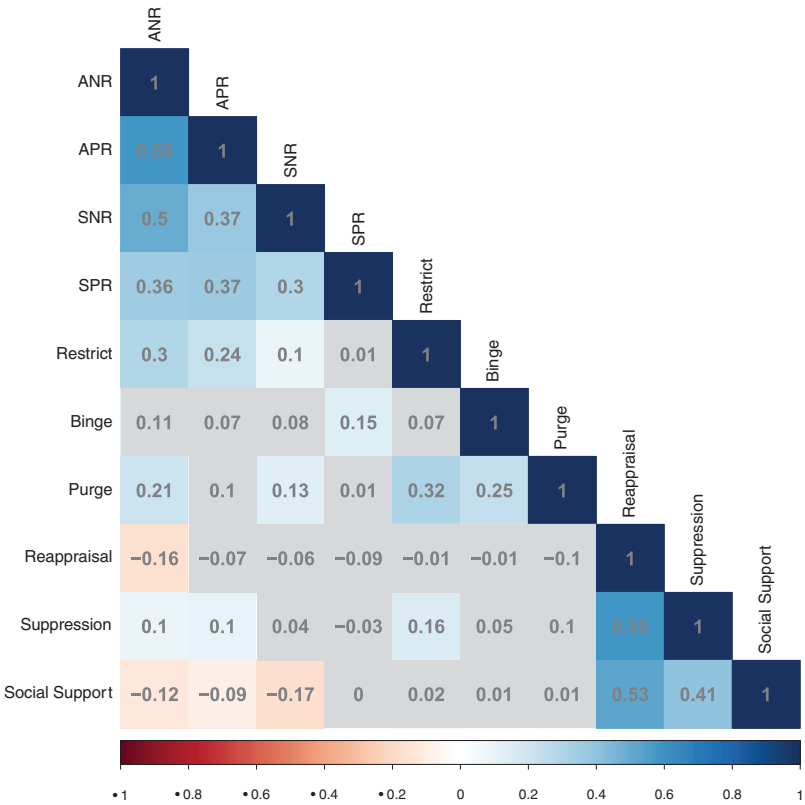
Factor Loadings of Exploratory Factor Analysis of Restrictive Eating Functions in Study 1



Note. APR = automatic positive reinforcement; ANR = automatic negative reinforcement; SPR = social positive reinforcement; SNR = social negative reinforcement. See the online article for the color version of this figure.

Figure 4

Correlations Among Restrictive Eating Functions and Clinical Characteristics in Study 1 (N = 457 Adolescents)



Note. Nonsignificant correlations are in gray. ANR = automatic negative reinforcement; APR = automatic positive reinforcement; SNR = social negative reinforcement; SPR = social positive reinforcement. Restrict, binge, and purge all refer to past-month frequency of behaviors. See the online article for the color version of this figure.

automatic negative, automatic positive, or social positive functions.

Discussion

In a large sample of adolescents, the four-factor model, which has been previously found to describe motivations for NSSI, binge eating, and purging, was extended to restrictive eating. In contrast with the literature on functions of these other behaviors, which have been found to primarily serve automatic negative reinforcement (Nock & Prinstein, 2004; Wedig & Nock, 2010), items related to automatic positive reinforcement were most highly endorsed for restrictive eating. Moreover, although control items loaded onto the automatic positive reinforcement function, rather than emerging as a fifth factor in the model, control items were among the most highly endorsed reasons for restricting. Finally, restricting for automatic functions was associated with greater use of maladaptive emotion regulation strategies and less use of adaptive emotion regulation strategies, and restricting for social negative reinforcement was associated with less perceived social support, supporting the construct validity of these functions. Although sample sizes for eating disorder diagnoses were unbalanced, results also suggested functions may differ by diagnosis, such that adolescents with BN may restrict for social negative reinforcement more than those with OSFED. However, findings relating to diagnostic differences warrant replication, given the limited statistical power with a relatively small sample size and underrepresentation of certain diagnoses in these analyses. Study 1 provided novel information on restrictive eating functions in a large sample of adolescents. Study 2 sought to replicate and extend these results with adults.

Study 2

Method

Participants and Procedure

Similar to Study 1, participants were recruited online. Given age differences in social media platform usage, recruitment for Study 2 occurred primarily on Reddit.com. We obtained approval from six forum moderators (e.g., reddit.com/r/eating_disorders) and posted study advertisements on each forum, similar to the process in our previous work (Fox, O'Sullivan, et al., 2019). Interested forum members completed a brief screener to determine eligibility (age ≥ 18 years, English speaking, 2+ episodes of past-

month restrictive eating, binge eating, purging, and/or NSSI). As with Study 1, we used filler items to obscure inclusion criteria. The Harvard University IRB approved all procedures (IRB protocol number/study title: IRB17-1245; "ED & NSSI"). Of note, results pertaining to other hypotheses from this study have been reported elsewhere (Fox, Wang, et al., 2019).

After completing the screener (N = 459), 169 qualified participants provided informed consent, completed study questionnaires, and were compensated with a $10 gift card. The final sample included 145 participants (M_{age} = 24.02, SD = 5.47) with 2+ past-month restrictive eating episodes (M_{BMI} = 23.20, SD = 6.99). Most participants (n = 125; 86%) reported female sex assigned at birth, and most reported female gender (n = 116; 80%). A total of 66 participants (46%) identified as heterosexual, 47 (32%) as bisexual, 12 (8%) as gay or lesbian, and four (3%) as pansexual. Regarding race/ethnicity, 105 participants (72%) identified as White/Caucasian, six (4%) as Hispanic/Latino, three (2%) as Black/African American, nine (6%) as Asian/Asian American/Pacific Islander, and 14 (10%) as biracial or multiracial.

Measures

All measures from Study 1 were included in Study 2, with the exception of the MSPSS. Study 2 used adult versions of the EDE-Q and ERQ rather than youth/child versions. In addition, in Study 2 the DRS asked participants to select past-month restrictive eating episodes (0, 1, 2–4, 5–10, 11–20, 21+ times), rather than allowing participants to write their own estimate.

Data Analysis

Following Study 1, we used descriptive statistics to examine clinical characteristics and average endorsement of restrictive eating items. Next, we used a confirmatory factor analysis (CFA) to test the four-function model identified in Study 1, using standard fit indices: comparative fit index (CFI) $\geq$ .90, TLI $\geq$ .95, RMSEA $\leq$ .06, and SRMR $\leq$ .08 (Hu & Bentler, 1999). Finally, we tested for differences in functions using a multilevel model and compared functions across diagnoses using linear regression models (both adjusted with Tukey's HSD to evaluate pairwise significant differences). We also evaluated correlations with clinical characteristics.

Results

Clinical Characteristics and Frequency of Restrictive Eating

Most participants (n = 89, 61%) endorsed 11–20 past-month restricting episodes. Participants reported an average of 7.34 past-month binge eating (SD = 12.00, range = 0–80) and 5.06 purging (SD = 12.84, range = 0–80) episodes. Average EDE-Q score was 4.95 (SD = 1.50), well within the clinical range, indicating high clinical severity. Using the EDE-Q diagnostic algorithm, 10 participants (6.9%) met criteria for AN, 21 (14.5%) for BN, 43 (29.7%) for BED, and 69 (47.6%) for OSFED; two (1.4%) participants did not meet criteria for an eating disorder.

Table 1 presents average endorsement for each item and percentage of participants endorsing items "sometimes" or "often." The most highly endorsed items were restricting to feel in control of one's body, feel in control of one's life, feel proud, punish oneself, and feel good.

Confirmatory Factor Analysis

A CFA indicated a good fit for the four-factor model from Study 1 across a variety of fit indices: CFI = .97, TLI = .97, RMSEA = .07 (90% CI [.06, .08]), and SRMR = .09.

Comparisons Among Functions and Clinical Characteristics

There were significant differences in endorsement of the four functions (F(3, 432) = 164.71, $p < .001$). Endorsement of automatic positive reinforcement functions was significantly higher than all other functions (ps $< .001$). Endorsement of automatic negative reinforcement functions was also significantly higher than social functions (ps $< .001$). There were no significant differences in social positive and negative functions (p = .47).

Correlations between functions and clinical characteristics (see Figure 5) found all four functions were all correlated with greater past-month restricting (all rs $> .39$, ps $< .001$). Automatic negative and positive reinforcement were correlated with greater past-month purging (rs = .54 and .55, respectively, ps $< .001$), and automatic negative reinforcement was correlated with greater past-month binge eating (r = .38, p = .01). Restricting for social positive reinforcement was weakly correlated with less emotional suppression ($r = -.17$, p = .046).

There were significant differences in automatic negative reinforcement (F(4, 140) = 3.33, p = .01); individuals with AN scored significantly higher than those with OSFED (p = .03). There also were significant differences in automatic positive reinforcement (F(4, 140) = 2.64, p = .04); individuals with AN scored significantly higher than those without an eating disorder (p = .04).

Discussion

Study 2 examined the four-function model of restrictive eating in a transdiagnostic adult sample. Results demonstrated this model was a good fit and items loaded onto the four factors in the same manner as the adolescent sample. Replicating Study 1 results, items assessing automatic positive reinforcement, including items about control, were the most highly endorsed. However, unlike Study 1, automatic negative and positive functions were not significantly correlated with either adaptive or maladaptive emotion regulation strategies. Although exploratory analyses demonstrated differences in functions by diagnosis, the pattern differed from Study 1, with individuals with AN demonstrating the highest scores on automatic functions. The AN sample in this study, as in Study 1, was small, limiting the ability to assess functions of restrictive eating in the clinical group most commonly characterized by extreme restrictive eating. In Study 3 we sought to replicate and further extend the results of Studies 1 and 2 using a rigorously defined group of participants with acute or recently weight restored AN.

Study 3

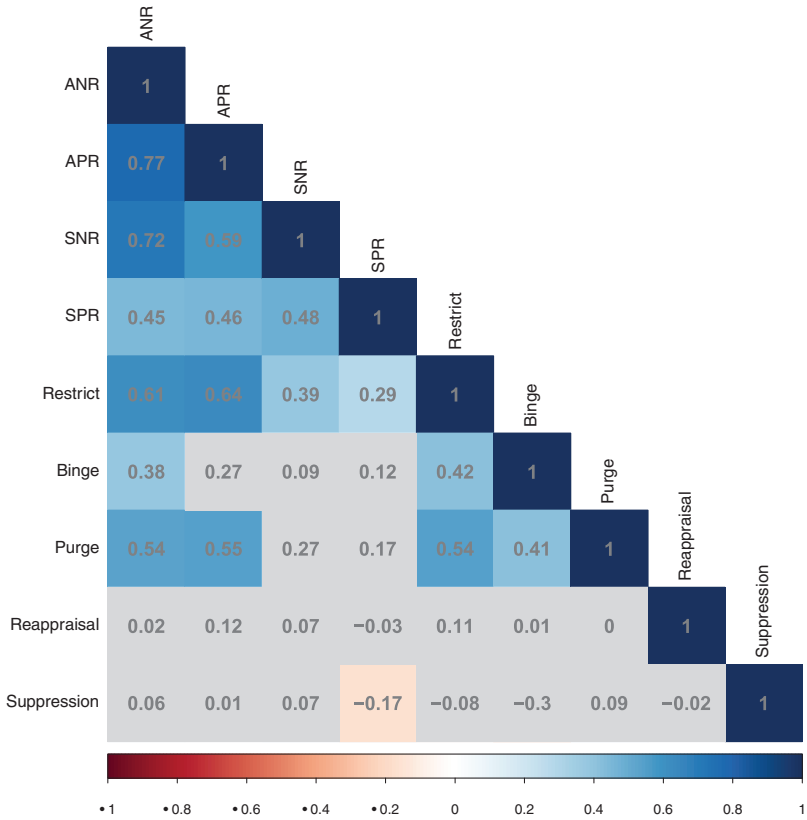
Method

Participants and Procedure

Participants were recruited as part of two larger studies investigating decision-making processes influencing AN at the University of Minnesota. Participants were recruited from advertisements in

Figure 5

Correlations Among Restrictive Eating Functions and Clinical Characteristics in Study 2 (N = 145 Adults)



Note. Nonsignificant correlations are in gray. ANR = automatic negative reinforcement; APR = automatic positive reinforcement; SNR = social negative reinforcement; SPR = social positive reinforcement. Restrict, binge, and purge all refer to past-month frequency of behaviors. See the online article for the color version of this figure.

university, treatment, and community settings, clinician referrals, and a recruitment database. Interested individuals were invited to an in-person visit to confirm eligibility (age ≥ 18 years, English speaking, past-year AN diagnosis). Trained research staff measured height and weight in the clinic and conferred AN diagnosis using the Structured Clinical Interview for *Diagnostic and Statistical Manual of Mental Disorders-Fifth Edition* (*DSM–5*, Research Version (SCID-5; First et al., 2015). All procedures were approved by the University of Minnesota (IRB protocol numbers/study titles: STUDY00000818 "Neural Correlates of Reward and Symptom Expression in Anorexia Nervosa" and STUDY00002308 "Goal-based Learning and Habit in Anorexia Nervosa") and participants completed informed consent before engaging in any research procedures. As completion of these questionnaires constituted a small portion of two larger multimethod studies, participants were compensated commensurate with the procedures completed.

A total of 45 participants (n = 18 acute AN, n = 27 recently weight-restored AN, M_{BMI} = 18.81, SD = 1.99) who met eligibility criteria completed study questionnaires and interviews. Most participants (n = 43; 95.6%) reported female gender (one participant identified as male and one as nonbinary) and mean age was 27.40 (SD = 11.67, range = 18–59) years. Regarding race/ethnicity, 41 participants (91.1%) identified as White/Caucasian, 1 (2.2%) as Asian, 1 (2.2%) as Hispanic/Latino(a), 1 (2.2%) as Native American, and one (2.2%) as more than one race/ethnicity.

Measures

As in Studies 1 and 2, the FAMB and DRS were used to assess functions and frequency of restrictive eating, respectively. Study 3 used the interview version of the Eating Disorder Examination (EDE-17; Fairburn, 2008) rather than the self-report version. In addition, this study utilized the Difficulties in Emotion Regulation Scale-16 (DERS-16; Bjureberg et al., 2016) total score, rather than the ERQ, to assess emotion regulation abilities. The DERS-16 is a shortened version of the original 36-item DERS that assesses a range of problems in emotion regulation (difficulty identifying and differentiating emotions, inhibiting impulses and engaging in goal-directed behavior when distressed, accepting negative emotions, and accessing adaptive emotion regulation skills). The DERS-16 has shown strong fidelity to the original version of the DERS (Bjureberg et al., 2016). AN illness duration was assessed with the SCID-5.

Data Analysis

In line with Studies 1 and 2, we used descriptive statistics to examine clinical characteristics of the sample and average endorsement of restrictive eating items. Given the relatively small sample size in Study 3, we do not report a CFA of restrictive eating functions in this sample (MacCallum et al., 1999). Consistent with both prior studies, we examined differences in endorsement between each of the four functions and correlations between the four functions and clinical characteristics (eating disorder behavior frequency, emotion regulation).

Results

Clinical Characteristics and Frequency of Restrictive Eating

Participants reported restrictive eating an average of 17.26 days over the past month (SD = 10.33, range = 0–28). Participants also endorsed an average of .33 past-month binge eating (SD = .88, range = 0–4), and 1.98 purging (SD = 4.68, range = 0–22) episodes. Average EDE score was 2.55 (SD = 1.27), consistent with prior research demonstrating lower EDE scores for individuals with AN, likely due to minimization of symptoms, ego-syntonic nature of AN, and that this measure was not specifically designed to assess AN severity (Binford et al., 2005). Average illness duration was 12.71 (SD = 13.31, range = 1–47) years.

Table 1 presents average item endorsement and percentage of participants endorsing each item "sometimes" or "often." The most highly endorsed items were restricting to cope with negative emotions, escape negative feelings, feel in control of one's body, reduce anxiety, feel in control of one's life, and feel good. Endorsement of different items did not differ by acute or weight-restored AN status ($t(40) = -.04$ to 1.68, ps = .10 to .97); therefore, these groups were combined in all analyses.

Comparisons Among Functions and Clinical Characteristics

There were significant differences in endorsement of the four functions ($F(3, 132) = 62.61$, $p < .001$); endorsement of automatic positive reinforcement functions was significantly higher than social functions (ps $< .001$). Endorsement of automatic negative reinforcement functions was also significantly higher than social functions (ps $< .001$). There were no significant differences between automatic positive and negative functions ($p = .07$) or between social positive and negative functions ($p = .64$).

Correlations between the four functions and clinical characteristics are shown in Figure 6. Results indicated that automatic negative ($r = .37$, $p = .014$), automatic positive ($r = .40$, $p = .008$), and social negative functions ($r = .33$, $p = .028$) were associated with greater past-month restrictive eating. Further, automatic negative ($r = .49$, $p < .001$) and automatic positive functions ($r = .43$, $p = .003$) were correlated with greater DERS total emotion regulation problems. No functions were significantly correlated with duration of illness or past-month binge eating or purging.

Discussion

Study 3 extended findings from Studies 1 and 2 by investigating the four-function model of restrictive eating among adults with a confirmed diagnosis of acute or recently weight-restored AN, a clinical group representing the classic prototype of disordered restrictive eating. As with Studies 1 and 2, items assessing automatic positive reinforcement functions, including control items, were among the most highly endorsed items. However, several negative reinforcement items ("to cope with negative emotions," "to reduce anxiety," and "to escape negative feelings") also were identified as top reasons for restrictive eating. This finding parallels results from Study 2 suggesting negative reinforcement may maintain restrictive eating more strongly for individuals with AN versus those with other or no eating disorder diagnoses. This study also replicated findings from the prior two samples indicating that degree of endorsement of automatic negative and positive reinforcement functions was significantly associated with restrictive eating frequency, and replicated the finding from Study 2 that social negative reinforcement was associated with restrictive eating. Finally, similar to Study 1, automatic negative and positive functions were significantly associated with emotion regulation difficulties, even when assessed with a different measure, further highlighting the validity of these functions.

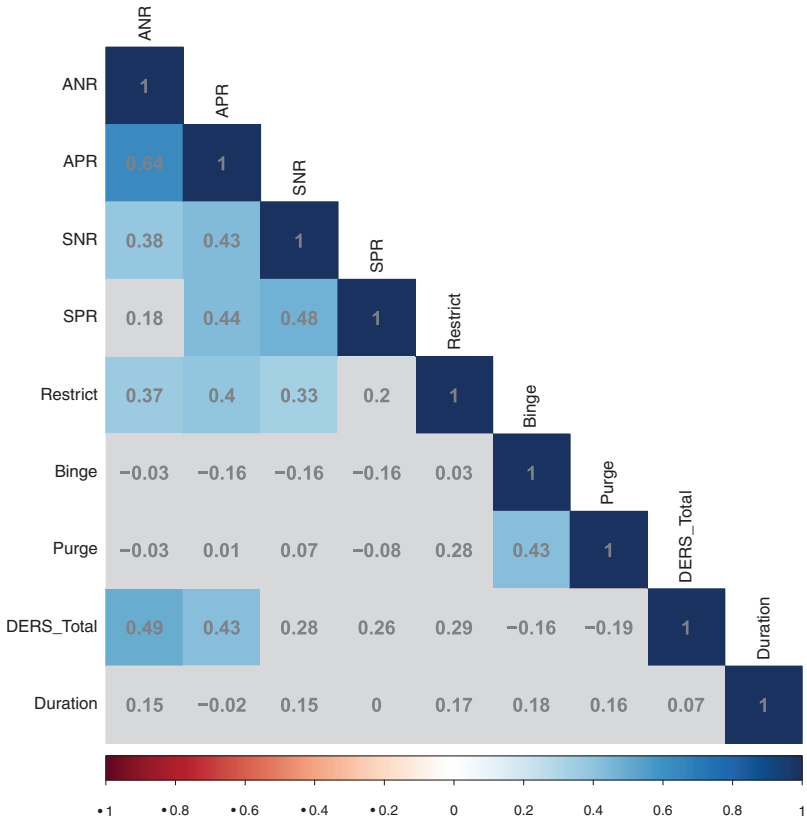
General Discussion

This series of studies provides the first direct investigation of restrictive eating functions within a well-established functional framework, yielding highly consistent findings across samples varying by developmental stage, diagnosis, illness stage/severity, and administration method (online vs in person). Results extend prior work examining binge eating, purging, and NSSI functions (Nock & Prinstein, 2004; Wedig & Nock, 2010), such that in three samples, we found restrictive eating is reinforced by automatic negative, automatic positive, social negative, and social positive functions.

There are several reasons functional assessment is important for advancing theory, research, and treatment of restrictive eating. First, identifying functions is critical for developing and implementing effective treatments. Although some treatments (e.g., DBT; Linehan, 1993) include techniques (e.g., chain analysis) to target functions maintaining maladaptive behaviors, including eating disorder behaviors, the emotion regulation theoretical model is formed on the implicit assumption is that behaviors primarily produce automatic negative reinforcement (Rudge et al., 2020). Further, DBT has been more often applied to treat binge eating and purging, rather than restrictive eating (Askew et al., 2020), and such functional analyses are not explicitly recommended or performed in many more standard treatments for restrictive eating (e.g., CBT-ED). Second, functional assessments allow for identification of shared functions maintaining frequently co-occurring maladaptive behaviors (e.g., restricting, purging, and NSSI). If similar functions underlie multiple behaviors, intervening on the function (rather than form) of behaviors could simultaneously reduce engagement in multiple behaviors. Third, this approach illustrates the heterogeneity of functions—both between- and within-person—that maintain restrictive eating. Although certain functions were endorsed more than others, all functions were endorsed by some participants, suggesting different people may need different interventions for the same behavior and functional assessments may be particularly useful for personalized treatment selection.

Figure 6

Correlations Among Restrictive Eating Functions and Clinical Characteristics in Study 3 (N = 45 Adults With Acute or Weight-Restored Anorexia Nervosa)



Note. Nonsignificant correlations are in gray. ANR = automatic negative reinforcement; APR = automatic positive reinforcement; SNR = social negative reinforcement; SPR = social positive reinforcement; DERS_Total = Difficulties in Emotion Regulation Questionnaire Total score; Restrict = past-month number of days engaging in restriction; Binge/purge = past-month episode frequency; duration = illness duration. See the online article for the color version of this figure.

Interestingly, unlike prior functional assessments of maladaptive behaviors, results from all three studies indicated restrictive eating is primarily maintained by automatic positive reinforcement. These findings are consistent with qualitative reports from individuals with AN describing restriction as yielding a sense of pride or self-confidence (Nordbø et al., 2006) and recent data demonstrating that specific facets of positive affect (e.g., pride) decrease before and increase after restrictive eating (Haynos et al., 2017). Emerging neuroimaging data also suggest that cues for restrictive eating yield activation in reward-related neural circuitry (Haynos et al., 2019). Considered in concert with this previous research, our results suggest positive reinforcement may be an essential treatment target for restrictive eating across eating disorder diagnoses and severity. Interventions may benefit from dissociating positive intrapersonal experiences from restrictive eating (e.g., cognitive training shifting attention away from positive aspects of restriction). Alternatively, interventions that help individuals identify and intentionally increase positive experiences that serve the same automatic positive function (e.g., skills, hobbies, and careers where control and pride can be generated), may be useful in reducing maladaptive restrictive eating by providing alternate methods of upregulating positive affect. Indeed, emerging evidence suggests the efficacy of treatments targeting increasing positive affect for depression and anxiety (Craske et al., 2019). Additionally, given that positive reinforcement derived may maintain the egosyntonic nature of restrictive eating, value-based interventions may be helpful in identify alternate sources of positive self-concept (Juarascio et al., 2013). Such approaches warrant investigation for reducing restrictive eating.

Although control did not emerge as a fifth factor, items assessing control were among the mostly highly endorsed in all samples. This provides empirical support for control functions of restrictive eating, which have long been of interest in clinical theories (Slade, 1982). All control items loaded onto the automatic positive factor, indicating that feeling in control of one's emotions, body, and environment is a desired, positive affective experience for individuals engaging in restrictive eating. Most prior control theories have suggested restrictive eating results from effortful and aversive self-control to suppress urges for more desired emotional or hedonic outcomes of eating (Bruch, 2001). However, the current

findings provide an alternative perspective that control may be positively reinforcing itself, and even more rewarding than positive consequences of eating. Cognitive and physical effort can be conditioned to subsume reward properties (Eisenberger, 1992); thus, with repeated positive reinforcement from controlling one's intake, the experience of control itself may become enjoyable. Self-control around food intake is also socially constructed as difficult and desirable and signals morality (Mooijman et al., 2018), which may also enhance reinforcing qualities of control. Further research is needed to parse aversive/suppressive elements from appetitive qualities of self-control relative to restrictive eating to better understand these relationships.

Results also indicated that restrictive eating functions were associated with clinical presentation and severity. In all studies, automatic functions were associated with greater frequency of restricting, aligning with theories suggesting intrapersonal reinforcement is more influential than social reinforcement in severe restrictive psychopathology (Walsh, 2013). However, it is notable that social negative reinforcement was associated with restrictive eating (though less strongly) in Studies 2 and 3, suggesting that escape from social pressures may be an important motivation for restriction for some individuals. Automatic negative functions were also associated with frequency of purging in Studies 1 and 2 (frequency of purging was low in Study 3), consistent with literature on automatic negative reinforcement functions of purging (Wedig & Nock, 2010). Further, AN diagnosis was associated with greater automatic negative functions in Studies 2 and 3. Given the importance of automatic negative reinforcement in other behaviors, these results suggest individuals might engage in multiple maladaptive behaviors to serve the same function. Future research examining this intriguing possibility could provide insight into whether high comorbidity between restrictive eating and other self-destructive behaviors (Wang et al., 2018, 2020) reflect shared reinforcement processes—and potential shared treatment targets to simultaneously intervene on multiple behaviors. This highlights the utility of assessing at the level of function, rather than form, to ensure the most potent interventions to treat the largest portion of symptoms are not overlooked.

There were some inconsistencies across studies in how functions differed by diagnoses. In Study 1, adolescents with BN reported greater social negative reinforcement than those with OSFED; in Study 2, adults with AN reported greater automatic negative reinforcement than those with OSFED and greater automatic positive reinforcement than those without an eating disorder; and in Study 3, the AN sample endorsed more automatic negative reinforcement functions than the prior two samples. This could be due to differences in prevalence of diagnoses between studies (more OSFED in Study 1, more BN and BED in Study 2, only AN in Study 3), and unbalanced groups ($<$10% of individuals in Studies 1 and 2 meeting AN criteria).

The current investigation had numerous strengths, including three separate samples differing in age (adolescents vs. adult), diagnosis (acute and weight-restored AN, BN, OSFED, no eating disorder), illness stage/severity, and use of online and in-person methods. There was diversity in race, sexual orientation, and gender identity (particularly in Study 1), which increases generalizability of these findings, though Study 3 was considerably less diverse, likely due to different recruitment methods (i.e., online vs. in-person study procedures) and a more homogeneously defined clinical sample. In addition, the clinical severity of all samples increases the confidence that these findings will extend to broader eating disorder populations.

There were also limitations, including the cross-sectional and self-report nature of these studies. The FAMB included items assessing reasons for engaging in restrictive eating that were developed from a robust and established theoretical framework (Nock & Prinstein, 2004; Wedig & Nock, 2010), but we did not provide an option for participants to write in their own responses, which may have highlighted additional processes reinforcing restrictive eating. This measure also may conflate restriction frequency with function, by asking participants how often they engage in restrictive eating for certain reasons. However, because functions were differentially associated with severity indicators, we do not believe that this impacted study findings. Further, although we replicated results across adolescents and adults, we did not examine changes in functions longitudinally. Functions were not associated with duration of illness in Study 3; however, this information was not collected in the other samples. Thus, it is unclear whether functions of restrictive eating may change, at an individual level, across developmental stages and duration of restrictive eating engagement. Future research examining if restrictive eating functions shift as individuals persist in this behavior could provide important information on mechanisms and treatment targets at various illness stages. In addition, sample sizes for eating disorder diagnoses were unbalanced, with few individuals in Studies 1 and 2 meeting criteria for AN, BN, and BED. Study 3 only included individuals with AN, many of whom may have sought treatment and were weight-restored. Although we did not find differences between weight-restored and acute participants in this sample, it is possible that different functions would have emerged with a larger acute sample. Future studies with larger samples of individuals with these disorders across the severity spectrum can yield insights on whether restrictive eating functions differ meaningfully across diagnoses.

Future research on the functions of restrictive eating could enhance the understanding of how restrictive eating functions change over time, whether different self-destructive behaviors serve the same function, and whether treatment selection based on functional assessments improves treatment outcomes. This line of research will build toward the ultimate goal of enhancing precise assessment and treatment of this common and destructive set of behaviors.

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